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UNCERTAINTIES OF OIL-SHALE DEVELOPMENT

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INTRODUCTION

The present flurry of development activity in the Piceance Basin culminates more than sixty years of effort to commercialize the area's rich oil-shale resources (Russell, 1980). The first boom period began shortly before 1920 when dwindling supplies of domestic crude prompted the filing of 9,000 placer claims on federal oil-shale lands in the basin. Numerous companies were soon formed to exploit the deposits, on both public and private lands, but none succeeded even though the U.S. Bureau of Mines supported this early venture by operating a pilot plant near Rulison between 1925-1927. Optimism faded quickly following the discovery of large oilfields in eastern Texas.

Interest revived in 1944 when Congress passed the Synthetic Liquid Fuels Act (Matzick and others, 1966). Essentially a prototype of the Energy Security Act signed by President Carter in June 1980, this legislation authorized the construction of demonstration plants to produce synthetic fuels from oil shale, coal, agricultural crops, forestry products, and other substances. Under its authority, the Bureau of Mines established the Oil-Shale Research Laboratory at Laramie, Wyoming, and the Oil-Shale Experiment Station at Anvil Points, located about 11 km west of Rifle, Colorado. Room-and-pillar mining, surface retorting, and shale-oil refining experiments were conducted at Anvil Points until 1956.

Private research efforts also resumed in the 1950s and 1960s, first by Union Oil Company, then by Colony Development Operation, Equity Oil Company, a consortium of companies who leased the Anvil Points facility, and others (Office Tech. Assess., 1980, p. 128-153). The Department of the Interior (1968) also moved to promote development by formulating a program to lease federal oil-shale lands, but when offered in the fall of 1968, the test program drew little participation from private industry (Anonymous, 1968).

After a short lull, development activities proceeded once again, albeit not without further interruptions (Novak, 1975, 1976a). Prospects for commercialization appeared to reach an all-time high in early 1974. OPEC had increased world oil prices dramatically, the Arab oil embargo had created public awareness of the need to increase domestic energy supplies, the Paraho Development group had reopened the Anvil Points facility, and Interior's new prototype leasing program had been enthusiastically supported by private industry. The two Colorado lease tracts, C-a and C-b, had received bonus bids of $210 and $118 million, respectively, both far higher than what Interior had anticipated. Colony Development Operation, then considered to have the most advanced technology, had become leaseholder of tract C-b and also had announced plans to build a commercial facility on its Dow property at the head of Parachute Creek.

Within a few months, however, Colony unexpectedly cancelled plans for commercial production on its private lands, and in 1976 both Colony and the Rio Blanco group, operator of tract C-a, requested suspension of diligence requirements on their federal leases. All four of the Colony partners eventually withdrew from tract C-b, turning over control to Occidental Oil Shale, who had been developing a modified in-situ process at its Logan Wash site since 1972. Oxy appeared for a time to be the only company still committed to commercial production.

Currently another boom period is in full swing, with at least 7 projects in some phase of oil-shale or sodium-mineral development (Table 1). Construction and operation workforce on these projects is expected to reach 2,253 by the end of this year (Comm. on Oil Shale, 1981). Shale-oil production is targeted at about 250,000 b/d in 1990, with the possibility of additional output by Mobil Oil Company. Several projects are also ongoing in the nearby Uinta Basin of Utah (Callahan, 1981).

Table 1. Oil-shale projects in the Piceance Basin, circa March 1981

Project	Development Plans
Cathedral Bluffs Shale Oil Co. (Occidental Oil Shale, Inc., and Tenneco Shale Oil Co.)	Operator of federal lease tract C-b; presently sinking shafts for production of 55,000 b/d in 1985 using modified in-situ retorting.
Chevron Shale Oil Company	Conducting environmental baseline studies on its private lands and determining which permits are necessary; plans to construct mine and retort module, with possible production of 50,000 b/d by early 1990.
Colony Development Operation (Exxon Co., U.S.A., and Tosco Corp.)	Has acquired major permits for construction of 47,000 b/d surface retort on its private lands by 1985; also building a new community, Battlement Mesa, to house oil-shale workers.
Multi Mineral Corp.	Is developing an experimental nahcolite mine at Horse Draw in cooperation with U.S. Bureau of Mines to be used in designing a commercial mine on an existing federal sodium lease; also hopes to acquire federal lease for production of nahcolite, soda ash, alumina, and shale oil.
Occidental Oil Shale, Inc.	Operating a modified in-situ research facility on private lease lands at Logan Wash for use in developing the Cathedral Bluffs (tract C-b) property; no plans for commercial production at this site.
Rio Blanco Oil Shale Co. (Gulf Oil Corp. and Standard Oil Co. of Indiana)	Operator of federal lease tract C-a; engaged in modified in-situ demonstration program that could lead to production of 50,000 b/d by 1987; also examining proposal for open pit mine and surface retorting.
Union Oil Company	10,000 b/d module now under construction on private lands to be completed by 1983; 50,000 b/d facility using surface retorting to be onstream by 1988.

Data abstracted from Callahan (1981).

If history provides insight to the future, then current optimisn regarding development must be tempered with caution. Oil shalE remains a high-risk investment because of the large and possibly unreliable plant cost estimates, technical uncertainties, uncer tainty of future world oil prices, and uncertainty of government support in the form of financial assistance or other incentives. P full discussion of these issues is contained in a report recently sub' mitted to Congress by the Office of Technology Assessment (1980). Liberal use has been made of this report in the followinE sections.

TECHNOLOGY AND PLANT COSTS

The capital and operating costs of shale-oil production are known to be large, but just how large is still a matter of some speculation. Table 2 shows the experience of one company in estimating capital costs for a 46,000 b/d facility using underground mining and TOSCO retorting. Reasons for the tremendous escalation in plant costs include inflationary price increases, especially in the industrial sector supplying plant equipment, increased environmental regulations, and improved engineering knowledge (Office Tech. Assess., 180, p. 186-189). The large cost increase between early and late 1974, which prompted Colony Development to cancel plans for production on its Dow property, resulted primarily from more detailed evaluation of engineering design. The subsequent estimates represent updates of the late 1974 version. First-generation developers are understandably reluctant to commit themselves to full-scale production without first proceeding through the modular phase. Past experimental activity has occurred only at the pilot-plant or semiworks level, at least for surface retorting systems, which means that scaleup by a factor of 10 or more is needed to achieve commercial output. Building a modular retort, one of several identical units that would be integrated in a commercial plant, is itself a costly enterprise, requiring an investment of several hundred million dollars (Office Tech. Assess., 1980, p. 173). The alternative is to risk significant cost overruns because of unreliable or ineffective equipment design. At present, only the Colony group appears to have enough confidence in its technology to proceed directly to full-scale production.

Early entry into commercial production conveys some benefits as well as risks. If the industry grows rapidly, then the first few plants will have contracted for a significant share of U.S. engineering, construction, and manufacturing capacity. Since carrying charges on capital investment represent almost half the unit costs of shale-oil production, project operators would be willing to bid up prices for key equipment to avoid construction delays. The resulting hyperinflation during a crash program could increase real prices by 50 percent or more (Office Tech. Assess., 1980, p. 63, 187-188).

An upward revision of plant cost estimates may also be needed if developers must underwrite part of the financial costs of commu nity growth. Governor Lamm of Colorado has advocated raising the state's mineral severance taxes as one means of funding the socioeconomic costs of oil-shale and coal-related energy developments. So far the Republican-controlled Colorado General Assembly has resisted the governor's plea, but this could change if the financial burden on local and state government becomes too great. Large public investments will unquestionably be needed to accommodate growth in what is now an overwhelmingly rural area (Kilker, 1981; Office Tech. Assess., 1980, p. 419-473). The paucity of existing infrastructure has prompted Colony Development Operation to invest $60 million of its own money to build a new residential community for its workers (Anonymous, 1980). Other companies have aided local communities with smaller grants. How much assistance private industry may have to provide in the future, directly or through increased severance taxes, is unknown.

Table 2. Capital costs of oil-shale processing

Date	Estimated Cost ($ Million)
1968	138
1973	250–300
Early 1974	400–500
Late 1974	850–900
1976	960
1977	1,050
Feb. 1980	1,700

Date provided by Tosco Corp. and Colony Development Operation (Office Tech. Assess., 1980, Table 22, p. 186).

WORLD OIL PRICES

The strong revival of oil-shale activity over the past two years coincided with a doubling between January 1979-1980 of refinery costs for imported oil (Chase Manhattan Bank, 1979, 1980). In March 1980 the posted price of premium crude, which is the counterpart of upgraded shale oil, stood between $34 and $38 per barrel (Office Tech. Assess., 1980, p. 190). Shale oil is probably competitive within this price range, assuming that developers are willing to accept an aftertax profit of perhaps no more than 12 percent. A developer who commits nearly $2 billion to a shale-oil plant with a long payback period must be confident that future increases in production costs will lag behind the rising price of conventional crude. Chase Manhattan analysts (Emerson, 1980, p. 2) project that OPEC real prices will grow at just over 3 percent annually during the remainder of this decade, reaching an inflated $100 per barrel in 1990 or about $45 in constant 1980 dollars. Although this outlook should be encouraging to oil-shale developers, experiences of the 1970s demonstrate that production costs could escalate more rapidly than oil prices.

GOVERNMENT POLICIES

Oil-shale development occurs within an institutional framework of government policies that affect investment opportunities. Specific policies that have been criticized for delaying or discouraging investment include access to federal lands, unrealistic or uncertain environmental stipulations, bureaucratic permit requirements, lack of a coordinated national energy plan, and price controls on domestic oil. Only the price control issue has been resolved to date. First initiated under the general price freeze of 1971-1973, the controls evolved into a complex eight-tier system until abolished by President Reagan in early 1981, several months before they were scheduled to expire under existing law. Actually, part of the controls still persist in the form of the windfall profits tax enacted by Congress last year.

Access to federal lands is not a major impediment to first-generation plants, but additional leasing will be needed to encourage new entrants and to permit expansion of the industry much beyond the announced production level of existing developments. Although private lands comprise more than one-fifth of total acreage in the Piceance Basin (U.S. Dept. Interior, 1968, Tables A-1-A-2), their commercial potential is generally inferior to the federally-owned resources. Some tracts are too small to be commercially viable. Others contain thin or lean deposits, and almost none contain sodium minerals that could be recovered simultane-

ously to lower the cost of shale-oil production. The Interior Department presently is formulating a permanent leasing program and also may recommend changing the Mineral Leasing Act to allow leasing of larger tracts, allocation of more than 1 tract to a single company, and leasing of tracts solely for siting facilities or offsite waste disposal (Anonymous, 1981a).

Both plant costs and ultimate size of the industry will be affected by environmental regulations. To date, most attention has focused on the Clean Air Act, especially the Prevention of Significant Deterioration (PSD) component which limits new emissions in areas where the existing air is cleaner than that required by national ambient air quality standards. For oil-shale developers, this means meeting the Class II standards applicable to the Piceance Basin itself and the even more stringent Class I standards of the Flat Tops Wilderness, located some 30 kilometers to the east (Edmonds, 1981). The present system allots each facility a portion of the total allowable pollution increment on a first-come, first-served basis. Just how large an industry might be accommodated is problematical because of unreliable atmospheric dispersion models and uncertainty regarding emission levels from a mix of production technologies. EPA has established a provisional limit of 400,000 b/d based on certain simplifying assumptions. Congress is expected to modify the Clean Air Act later this year, with the PSD program receiving high priority (Crow, 1981).

Another environmental issue that could seriously impede oil-shale expansion is the existence of federally-listed endangered fish species in the White River, Green River, and Colorado River mainstem (Joseph and others, 1977). Protection of these species under provisions of the Endangered Species Act may prevent development or add materially to the costs of building water-storage facilities that will be needed to support shale-oil production. The Fish and Wildlife Service has already taken a very conservative stance on the White River Dam project, which could supply water to developers in Utah, and the Moon Lake Power Plant project on the Green River. The Service recently issued a negative biological opinion for the Moon Lake project even though it would deplete flows of the Green River by only 2 percent (U.S. Fish and Wildlife Service, 1980).

Environmental issues interface with another uncertainty, that of securing the multitude of local, state, and federal permits required at various stages of project development (Davidson, 1976; Novak, 1976b). Some government agencies issue both permits and regulations. Others give clearance to permit applications required by other agencies; for example, clearance from the National Park Service and State Historical Society regarding archaeological-historical sites must be obtained before the lead agency will issue its permit. Even after permits are issued, the possibility remains that stipulations may be changed at a later date. The resulting complexity and uncertainty provides opportunity for disruption of company planning schedules, contributes to inflationary costs when delays do occur, promotes additional costs if designs have to be altered, and poses the risk that insurmountable roadblocks will eventually be encountered. Congress tried unsuccessfully last year to resolve the permitting dilemma by proposing the creation of an Energy Mobilization Board. At the state level, Colorado has just established a voluntary Joint Review Process designed to expedite decisionmaking by coordinating permit applications and providing fuller public participation in the permitting process.

In the short term, the most crucial governmet policy would seem to be implementation of the Energy Security legislation enacted by Congress last year, which created a Synthetic Fuels Corporation empowered to assist private industry to develop oil shale and other synthetic sources by providing purchase agreements, loan guarantees, or direct loans. Provisional commitments of financial help have been made to the Union Oil project and to Tosco Corporation, one of the two Colony partners, under the program's initial phase (Anonymous, 1981b). This phase also included an unsuccessful application by Occidental Oil Shale, who may reapply as the program expands. However, the new Reagan administration opposes implementing the full scope of government aid. One of the President's first official acts was to fire the Corporation's chairman and board of directors (Anonymous, 1981c). Unless pushed by Congress, government financial assistance may languish rather than promote synthetic-fuel development.

CONCLUSIONS

Oil-shale development in the Piceance Basin has a long history of unfulfilled expectations. Most of the factors which discouraged commercialization in the past still remain; indeed, the uncertainties imposed by government regulation have increased rather than diminished. Nonetheless, the relatively large number of projects now poised to build modular or commercial facilities affords optimism that one or more first-generation plants will be constructed in the next few years. Only by taking this initial step will industry be able to clarify the technical and economic uncertainties that have plagued development for so long. Projections of how rapidly the industry might expand after this first endeavor, or at what production level it might eventually peak, are speculative issues better left to future analysts.

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